

UNITED STATES PATENT APPLICATION

of

TIMOTHY R. BRUMLEVE

KATSUMI FUKUTOME

STEVEN C. HANSEN

and

DUANE A. STAFFORD

for

A SOLID MERCURY RELEASING MATERIAL AND  
METHOD OF DOSING MERCURY INTO DISCHARGE LAMPS

## CLAIM OF PRIORITY

This application claims the priority of U.S. Provisional Patent Application S.N. 60/196,308 filed April 12, 2000.

## BACKGROUND OF THE INVENTION

The present invention relates generally to dosing mercury in discharge lamps. More specifically, the present invention relates to dosing a small quantity of mercury into the light emitting chamber of a discharge lamp using solid mercury-containing dispensers in the form of particles of high purity, uniform size, and uniform composition.

Discharge lamps such as cold cathode fluorescent lamps having a vaporizable lamp fill including mercury are commonly used for computer display backlighting and instrumentation illumination such as in an automobile or airplane. In the manufacture of such discharge lamps, it is necessary to introduce very small amounts of mercury into the light emitting chamber of the lamp. For example, a cold cathode fluorescent lamp typically includes about 0.1 mg up to about 10 mg of mercury depending on the size of the lamp. However, some discharge lamps may require as little as .001 mg or as much as 50 mg of mercury. While it is possible to introduce liquid mercury directly into the chamber, it is very difficult to obtain precise doses of such small quantities of mercury using this method due to the high surface tension of mercury. Consequently, lamps dosed by this method usually include more mercury than is needed for operation of the lamp leading to concerns with meeting government regulations on mercury content and to environmental concerns in the disposal of the lamps. Direct introduction of liquid

mercury into the chamber may also be impeded by retention of small droplets of mercury on the surface of the dosing tube.

There remains the practical question of how to dose such small quantities of mercury into the light emitting chamber of a discharge lamp. It is known to dose the mercury using an amalgam which releases mercury when the temperature of the amalgam is elevated. For example, U.S. Patent No. 3,957,328 to van der Wolfe et al. discloses a method of dosing mercury into the light emitting chamber of a lamp wherein an indium amalgam in a liquid or paste form is introduced and spread about the interior surface of an exhaust tube to increase the surface area thereof, and then the exhaust tube is connected in fluid communication with the light emitting chamber of the lamp. The amalgam is heated to effect release of the mercury from the amalgam into the chamber, leaving the dispensed indium in the exhaust tube for removal from the lamp therewith.

The method disclosed by van der Wolfe et al. suffers from several disadvantages. The amalgam is in the form of a liquid or paste and thus the precise amount of amalgam must be measured prior to introducing the amalgam into the exhaust tube of the lamp. Further, the amalgam must be introduced into the exhaust tube with the aid of a syringe and then the glob of amalgam must be spread evenly about the inner surface of the tube. The spreading of the amalgam requires rotation of the tube and, in some instances, a jet of gas such as air is required to sufficiently spread the amalgam.

To further facilitate the spreading of the amalgam in the exhaust tube, the

amalgam is introduced into the tube separate from the lamp prior to connecting the tube in fluid communication with the light emitting chamber of the lamp. Certain process steps in the manufacture of the lamp must be performed after the connection of the exhaust tube (containing the amalgam) and require parts of the lamp to be exposed to high temperatures. Thus the amalgam may be exposed to high temperatures during certain lamp process steps which may lead to premature release of mercury from the amalgam, and cooling of the amalgam may be required to prevent premature release of the mercury.

Still further, the amalgam paste is susceptible to contamination by air and moisture which may lead to the introduction of contaminants into the chamber during release of the mercury.

Thus there remains a need for a method of dosing small quantities of mercury into discharge lamps in an easily fabricated and dosed solid mercury-containing dispenser of high purity, uniform size, and uniform composition.

Accordingly, it is an object of the present invention to obviate the deficiencies of the known prior art and to provide a novel mercury-containing dispenser and method.

It is another object of the present invention to provide a novel particle suitable for dispensing small quantities of mercury into a discharge lamp.

It is yet another object of the present invention to obviate the deficiencies of the known prior art and to provide a novel method of dosing mercury into a discharge lamp.

It is still another object of the present invention to provide a novel method of dosing a discharge lamp with small quantities of mercury dispensed from a solid amalgam particle.

It is a further object of the present invention to provide a method of dosing a lamp with small quantities of mercury which reduces the introduction of impurities into the lamp.

These and many other objects and advantages of the present invention will be readily apparent to one skilled in the art to which the invention pertains from a perusal of the claims, the appended drawings, and the following detailed description of the preferred embodiments.

#### DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustrating a discharge lamp having an amalgam particle contained within the exhaust tube according to the present invention.

Figure 2 is a graphical illustration of the mercury evolution in a reduced pressure atmosphere from particles formed according to Example 1 of the present invention.

Figure 3 is a graphical illustration of the mercury evolution in a reduced pressure atmosphere from particles formed according to Example 2 of the present invention.

Figure 4 is a graphical illustration of the mercury evolution in a reduced pressure atmosphere from particles formed according to Example 3 of the present invention.

Figure 5 is a graphical illustration of the mercury evolution in a reduced pressure

atmosphere from particles formed according to Example 4 of the present invention.

### DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention finds utility in dosing the desired quantities of mercury in all types and sizes of discharge lamps. By way of example only, certain aspects of the present invention may be easily understood in the embodiment of an amalgam particle and method of dosing small quantities of mercury in a cold cathode discharge lamp in which the lamp fill material is dosed into the light emitting chamber through an extended tubular end portion of the lamp body.

It has been discovered that a mercury-containing dispenser suitable for dispensing a small quantity of mercury into the light emitting chamber of a discharge lamp may take the form of one or more solid particles formed from a molten mixture of mercury and one or more amalgamative metals. The temperature of the particle may be elevated to effect release of substantially all of the mercury contained therein without any substantial release of the one or more amalgamative metals.

The one or more amalgamative metals must form a stable amalgam at room temperature and must release essentially only mercury when the temperature of the amalgam is elevated to a temperature within a certain temperature range. The temperature range in which the amalgam releases essentially only mercury depends on the composition of the amalgam, a temperature readily determined by one having skill in the art. The amalgamative metals suitable for forming the solid mercury dispenser

include zinc, tin, indium, lead, copper, cadmium, bismuth, silver, and gold, and combinations thereof such as alloys.

The particles may be formed by admixing the desired quantity of mercury with the one or more amalgamative metals, melting the admixture, and forming particles from the molten admixture. The amount of amalgamative metal in the particle is determined by the desire to have a particle large enough to facilitate handling and prevent introduction of the particle and the dispensed amalgamative metal into the light emitting chamber, yet not too large that the particle is precluded from being placed in close proximity to the light emitting chamber during the mercury dosing process.

U.S. Patent No. 3,676,534 to Anderson dated July, 1972 and assigned to the assignee of the present invention, the content of which is hereby incorporated by reference, discloses a process for forming uniformly sized particles by forcing a homogeneous melt through an orifice of known diameter at a known velocity and acoustically or electromechanically breaking the molten jet into controlled lengths.

An alternative process is described in the Anderson U.S. Patent No. 4,201,739 dated May, 1980 and assigned to the assignee of the present invention, the content of which is hereby incorporated by reference. In that Anderson patent, particles are formed by the controlled wetting of an orifice which allows the dripping of a molten admixture to form spheres of a larger diameter.

Yet another process for forming particles from a molten admixture of materials is

disclosed in Yoshino U.S. Patent No. 4,615,846, the content of which is hereby incorporated by reference.

Particles suitable for dispensing mercury into discharge lamps may be formed by mixing mercury with one or more amalgamative metals, melting the admixture, and forming the particles from the molten admixture according to the processes disclosed by Anderson and Yoshino et al., or any other suitable process for forming particles from a molten admixture of materials. Particles containing as little as 0.001 mg or as much as 50 mg of mercury and ranging between 0.5 and 75 weight percent mercury may be produced. Particles for introducing mercury into cold cathode fluorescent lamps typically include between about 0.1 mg and 10 mg of mercury.

The particles are typically produced as spheres having an average diameter between about 50 and about 3,000 microns, and preferably between about 150 and about 1,200 microns. However, such particles may be produced in the dripping process described above with a diameter between about 1600 and about 3000 microns, preferably between about 1750 and about 2500 microns. The process of Yoshino et al. may produce particles having diameters greater than 1000 microns.

With reference to Figure 1, a cold cathode discharge lamp 10 includes a lamp body 12 formed from light transmissive material such as glass. The body 12 forms a light emitting chamber 14 intermediate end portions 16,18. A pair of spaced apart electrodes 20 are positioned coaxially, one in each end portion. The body 12 is elongated

beyond the electrode 20 positioned therein and may be sealed at the end portion 22 thereof to form a mercury dispensing chamber 24. The chamber 24 may be sealed by tipping off the end portion 22 or by connection of a gas supply hose (not shown) to the end portion 22. Fluid communication between the mercury dispensing chamber 24 and the light emitting chamber 14 is maintained through the passage 28 until the mercury is dispensed into the chamber 14.

One or more mercury dispensing particles 26 may be placed within the mercury dispensing chamber 24 prior to sealing the end portion 22. The particles 26 must be small enough to be contained within the chamber 24, but large enough to prevent passage of the particles 26 and the dispensed amalgamative metal into the chamber 14 through the fluid passage 28. An impediment to the passage of the particle 26 through the passage 28 such as the glass bead 29 may be positioned within the chamber 24.

Once the particles are sealed within the chamber 24, the temperature of the particles 26 may be elevated to effect release of the mercury from the particles 26 by locally heating the portion of the chamber 24 containing the particles 26. The chamber 24 may be locally heated by any conventional means such as a locally directed flame or radiation. The temperature differential between the locally heated chamber 24 and the chamber 14 will drive the released mercury vapor into the cooler chamber 14 through the fluid passage 28 where the mercury will condense.

The particles must be heated to a temperature which is sufficient to effect release

of mercury, but limited to prevent release of amalgamative metal from the particle and limited to prevent the softening of the lamp components formed from glass. The desired temperature depends on the composition of the particles, but is typically within the range of about 250°C to about 425°C. Desirably, substantially all of the mercury contained in the particle is released in less than four minutes after the temperature of the particle is elevated.

Once the mercury is dispensed into the chamber 14, the chamber 14 may be sealed by conventional means such as shrink sealing the end portion 18 at the portion forming the passage 28, and the elongated end portion 18 may be removed beyond the shrink seal along with the residue of the dispensed amalgamative metal.

In the preferred embodiment of the present invention for use in dispensing mercury into a cold cathode fluorescent lamp, the particles are formed by admixing mercury with bismuth and tin, melting the admixture, and forming particles from the melted admixture.

The particles of the present invention provide a solid mercury-containing dispenser which may be easily dosed into close proximity to the light emitting chamber of a discharge lamp so that the mercury may be released from the dispenser into the chamber by heating the dispenser. The particles may be formed to include high purity, uniform size, and uniform composition. The particles are suitable for dispensing small amounts of mercury into cold cathode fluorescent lamps, as well as all sizes and types of

discharge lamps including conventional fluorescent lamps, compact fluorescent lamps, and metal halide lamps.

Further, the ease of positioning the particles in close proximity to the chamber allows placement of the particles after the completion of the steps in the manufacture of the lamp which may expose the particles to elevated temperatures, thereby preventing the premature release of mercury from the particles.

**Example 1:**

A particle is formed by admixing 16 g mercury with 48 g bismuth and 36 g tin, melting the admixture into a homogeneous melt, and solidifying the melt into 53 mg particles having a composition of about 16 weight percent mercury. The particles formed are generally spherical and have a diameter of about 2200  $\mu\text{m}$  and a quantity of about 8.5 mg of mercury. Figure 2 illustrates the mercury evolution from the particle when subjected to the illustrated temperature cycle in an atmosphere of argon at 1.4 torr.

**Example 2:**

A particle is formed by admixing 15 g mercury with 85 g indium, melting the admixture into a homogeneous melt, and solidifying the melt into 7.7 mg particles having a composition of about 15 weight percent mercury. The particles formed are generally spherical and have a diameter of about 1230  $\mu\text{m}$  and a quantity of about 1.2 mg of mercury. Figure 3 illustrates the mercury evolution from the particle when subjected to the illustrated temperature cycle in an atmosphere of argon at 1.6 torr.

**Example 3:**

A particle is formed by admixing 15.8 mg mercury with 184.2 g lead, melting the admixture into a homogeneous melt, and solidifying the melt into 6 mg particles having a composition of about 7.9 weight percent mercury. The particles formed are generally spherical and have a diameter of about 1000  $\mu\text{m}$  and a quantity of about 0.47 mg of mercury. Figure 4 illustrates the mercury evolution from the particle when subjected to the illustrated temperature cycle in an atmosphere of argon at 1.4 torr.

**Example 4:**

A particle is formed by admixing 300 g mercury with 700 g zinc, melting the admixture into a homogeneous melt, and solidifying the melt into 4.35 mg particles having a composition of about 30 weight percent mercury. The particles formed are generally spherical and have a diameter of about 1000  $\mu\text{m}$  and a quantity of about 1.3 mg of mercury. Figure 5 illustrates the mercury evolution from the particle when subjected to the illustrated temperature cycles in an atmosphere of argon at 1.4 torr.

While preferred embodiments of the present invention have been described, it is to be understood that the embodiments described are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof.